Kootenai River Fisheries Investigations:

Rainbow Trout Recruitment

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ABSTRACT

The objective of this study was to determine if juvenile production is limiting the population of rainbow trout *Oncorhynchus mykiss* in the Idaho reach of the Kootenai River. We used snorkeling and electrofishing techniques to estimate juvenile rainbow trout abundance in, and outmigration from, the Deep, Boulder, and Myrtle creek drainages in Idaho. The total population estimates for the three drainages estimated in 1997 were 30,023; 763; and 235; respectively. A rotary-screw trap was utilized to capture juvenile outmigrants for quantification of age at outmigration and total outmigration from the Deep Creek drainage to the Kootenai River. The total outmigrant estimate for 1997 from the Deep Creek drainage was 38,206 juvenile rainbow trout. Age determination based largely on scales suggests that most juvenile rainbow trout outmigration from the Deep Creek drainage occurs at age-1, during the spring runoff period. Forty-three adult rainbow trout captured in the Deep Creek drainage were tagged with $10.00 reward T-bar anchor tags in 1997. A total of three of these fish were harvested, all in Kootenay Lake, British Columbia. This suggests the possibility of an adfluvial component in the spawning population of the Deep Creek drainage.

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INTRODUCTION

The Kootenai River has undergone the recent loss of several once relatively productive fisheries (white sturgeon *Acipenser transmontanus*, burbot *Lota lota*, bull trout *Salvelinus confluentus*, kokanee *Oncorhynchus nerka kennerlyi*, and mountain whitefish *Prosopium williamsoni*) (Fredericks, in press). Currently, despite low densities, rainbow trout provide the most important fishery in the river.

Paragamian (1994) reported that, although poor, the rainbow fishery has remained relatively stable since the work of Partridge (1983). Partridge (1983) estimated angler catch rates of 0.05 rainbow trout/h in 1982, and Paragamian (1994) reported angler catch rates of 0.16 rainbow trout/h over a similar period of time in 1993 and 1994. For comparison, Schill (1991) summarized catch rates for a number of Idaho rivers, which ranged from 0.7 to 1.95 trout/hr.

Partridge (1983) and Paragamian (1994) both suggested recruitment is primarily from tributaries. Both authors reported high densities of juvenile trout in Deep Creek tributaries, but noted the limited suitable and/or accessible habitat. Partridge (1983) reported that most of the juvenile production in the Idaho reach of the Kootenai River was probably from Falls, Trail, and Ruby creeks and hypothesized that quantity and quality of spawning and rearing habitat was limiting the rainbow trout population. This hypothesis is largely dependent on the absence or near absence of successful spawning in the mainstem and a lack of recruitment from Montana tributaries. Data on Montana recruitment sources to the Idaho reach of the Kootenai River are lacking and to date, no studies have documented rainbow trout spawning in the mainstem Kootenai River in Idaho. However, researchers with Montana Fish, Wildlife, and Parks (MFWP) report counting 20-40 rainbow trout redds each year in the 2.5 km-long reach directly below Libby Dam (Steve Dalbey, MFWP, and personal communication).

There is little information available regarding river habitat use by juvenile or adult rainbow trout in the mainstem Kootenai River in Idaho. There are approximately 105 km of Kootenai River in Idaho with the following three distinct reaches based on habitat types (Figure 1): 1) the canyon reach (22 km) from the Montana border to the Moyie River, 2) the braided reach (10 km) from the Moyie River to Bonners Ferry, and 3) the meandering reach (73 km) from Bonners Ferry to the Canadian border. The meandering reach has been heavily altered by diking and probably has little potential to support fluvial rainbow trout. Based on substrate, velocity, and depth, the reaches above Bonners Ferry appear to be the most suitable adult rainbow trout habitat (Fredericks, in press), yet the sources of recruitment to this area are unknown. Juveniles produced in the Deep Creek drainage would have to travel upriver after emigrating from Deep Creek to utilize this habitat. Similar migrations have been documented in other salmonid stocks. Cutthroat trout *Oncorhynchus clarki* in Yellowstone Lake spawn, in part, in the outlet area of the Yellowstone River. Progeny from this stock have been shown to migrate upstream to the rearing area and are evidence of genetically controlled migration patterns (Raleigh and Chapman 1971; Bowler 1975). Other studies have demonstrated upstream migrations of salmonids from natal streams to rearing areas (Brannon 1967; Raleigh 1971).

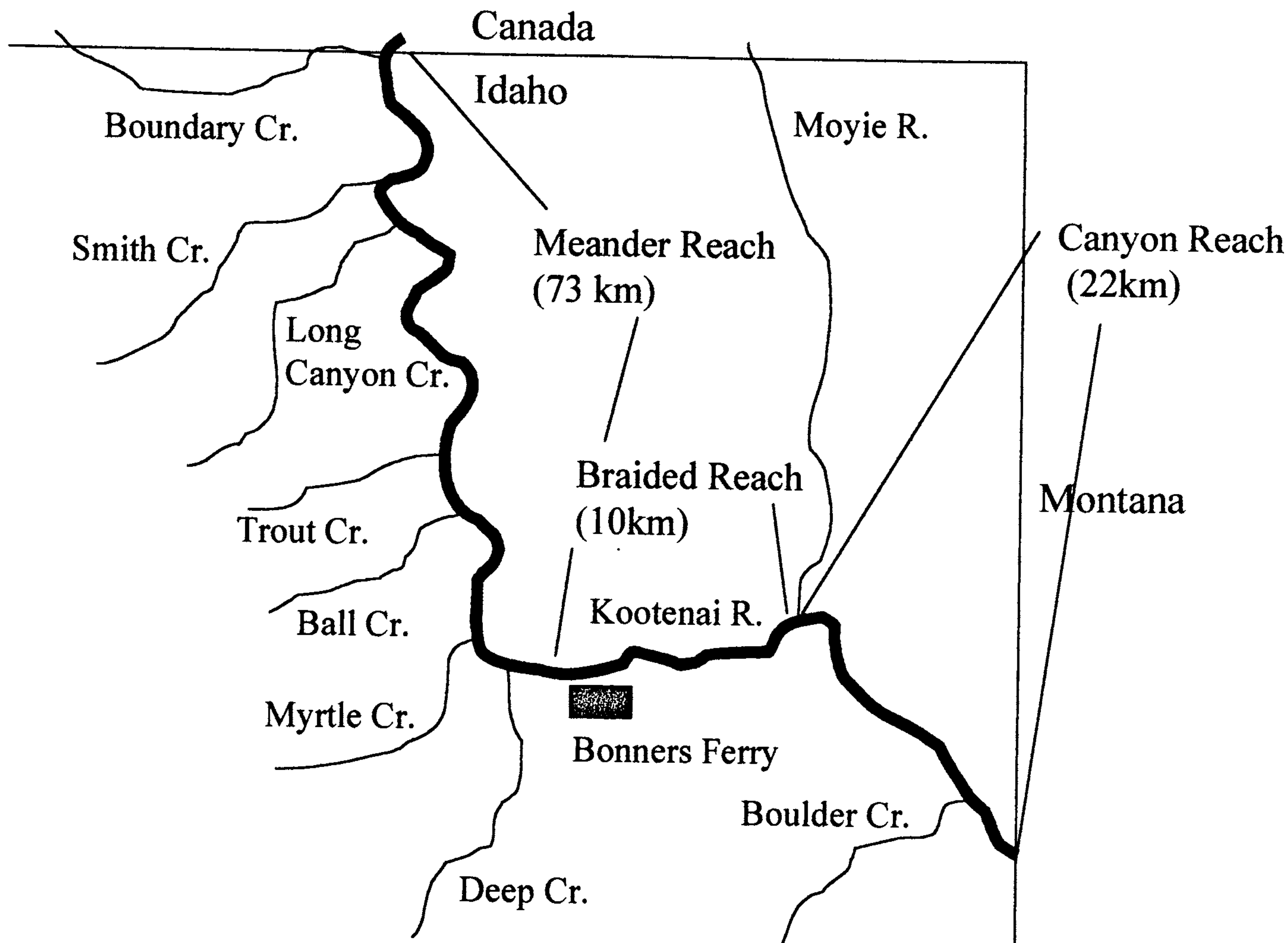


Figure 1. Map of the Idaho reach of the Kootenai River depicting the three broad habitat types and major tributaries.

The question of whether or not the system is recruitment limited can only be answered after we have obtained a numerical estimate of juveniles entering the river, an estimate of in-river survival, and an estimate of the carrying capacity of the Kootenai River for juvenile and adult rainbow trout. Also of importance is an understanding of the river habitat utilized by juvenile and adult rainbow trout. If the fishery is found to be recruitment limited resulting from insufficient juvenile production, it might be enhanced by improving and/or expanding spawning and rearing habitat in both tributaries and the mainstem. The fishery could potentially be enhanced through the stocking of juvenile rainbow trout.

The only documented fish plant occurring in recent decades in the Idaho reach of the Kootenai River itself occurred in 1972. A total of 100 juvenile Kamloops strain rainbow trout (the native interior redband trout of Kootenay Lake (Behnke 1992)), weighing a combined 10 pounds, were planted. Survival and angler exploitation rates for this plant were not assessed.

RESEARCH GOAL

Improve the rainbow trout fishery in the Kootenai River.

OBJECTIVE

Determine if the rainbow trout population in the Idaho reach of the Kootenai River is limited by juvenile production and survival.

METHODS

Deep Creek Basin-wide Estimate

We conducted an extensive population estimate of juvenile rainbow trout in the Kootenai River tributaries. Tributaries surveyed included: Boulder, Browns, Caribou, Deep, Dodge, Fall, Myrtle, Ruby, Snow, and Trail creeks. With the exception of Myrtle and Boulder creeks, all of the streams surveyed are Deep Creek tributaries (Figures 1 and 2). We focused on the Deep Creek drainage because previous studies indicated these streams comprised the majority of spawning and rearing habitat in the Idaho reach of the Kootenai River (Partridge 1983, Paragamian 1994).

We used the Basin-wide Visual Estimation Technique (BVET) (Hankin and Reeves 1988) as described by Dolloff et al.(1993) to estimate fish abundance. A basin-wide habitat inventory was conducted in the Deep, Myrtle, and Boulder creek drainages in 1996 to quantify available habitat for those portions of the drainages accessible to fluvial fish.

The BVET technique involves selecting a stratified subsample of habitat units from within each habitat type to be snorkeled for visual estimation of rainbow trout abundance. Rainbow trout observed were partitioned into three size groups: <76, 77 to 127, and >127 mm total length (TL). These length groups were chosen to reasonably approximate the lengths of age-0, age-1, and age-2 and older rainbow trout as reported by Fredericks (in press).

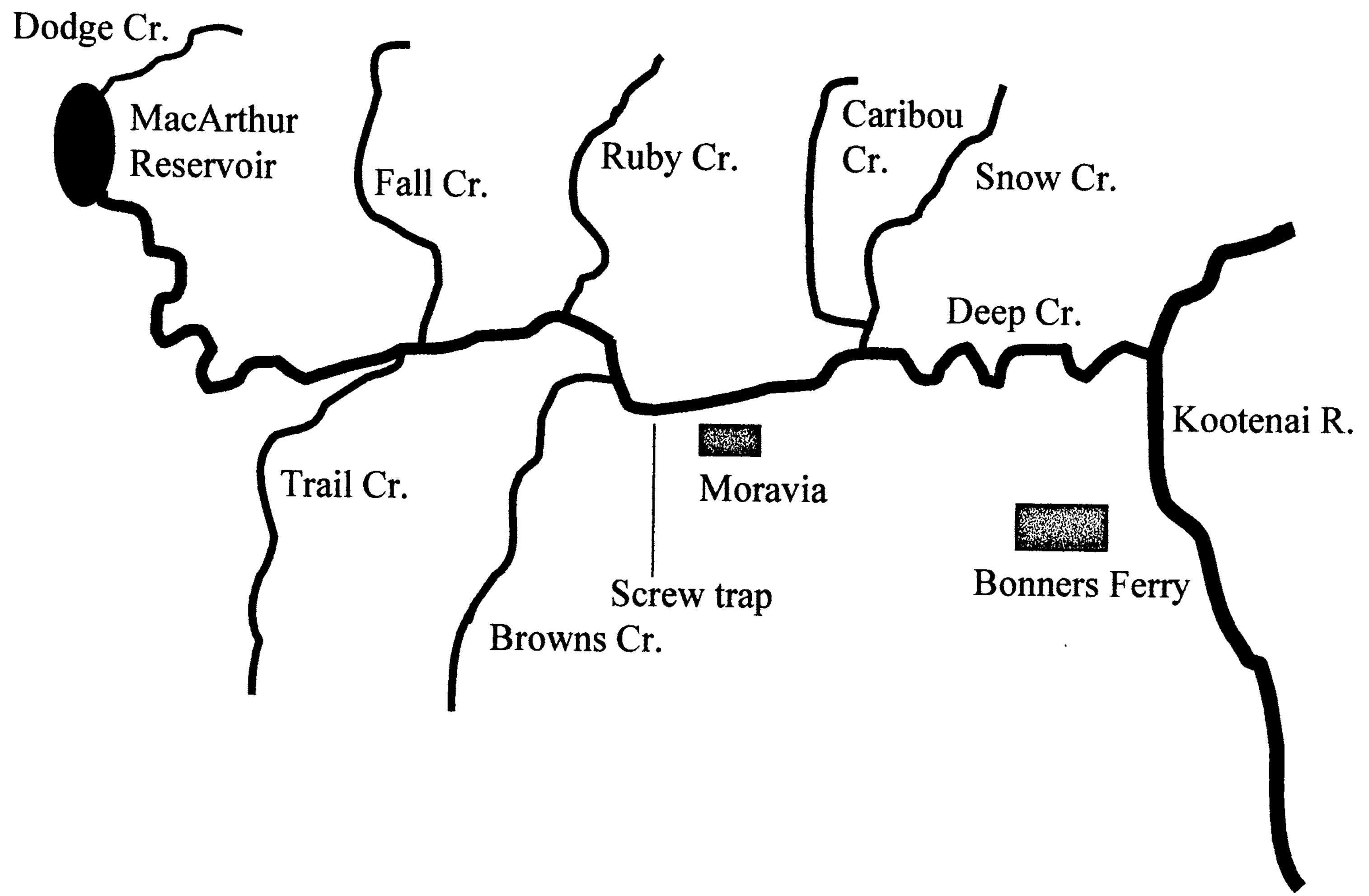


Figure 2. Deep Creek drainage map depicting major tributaries and location of screw trap.

Paired snorkeling and multiple-pass depletion electrofishing estimates were conducted in a second subsample of units taken from within the first subsample. Block nets were used to maintain population closure during depletion estimates which typically consisted of three or more removal passes. Two passes were used when capture probabilities exceeded 0.8. Depletion estimates were analyzed by size group (age class) using the Microfish (Van Deventer and Platts 1989) software package. This provided a ratio of the observed density (snorkeling) to the true density (multiple-pass electrofishing depletion estimate). For practical purposes, the variance of the multiple pass depletion is assumed to be zero. This calibration ratio of observed to true density was applied to the entire snorkel sample in the Deep Creek drainage by habitat type and age class to correct for bias associated with the visual estimates (Hankin and Reeves 1988).

To minimize potential bias associated with different individuals conducting habitat typing from 1996 to 1997, we pooled habitat types from the original 1996 habitat survey and the 1997 snorkel data into two distinct categories: 1) fast water (riffles and pocket water) and 2) slow water (pools and glides) for analysis. A total of four calibration ratios were developed for the snorkel estimates: 1) age-0 fast water, 2) age-0 slow water, 3) age-1 and older fast water, 4) age-1 and older slow water. We were unable to create a separate correction factor for age-2 and older (> 127 mm) due to low abundance.

The mean number of fish by size class per habitat type was calculated from the snorkel data. This value was then corrected using the calibration ratio for the appropriate age class and habitat type. The corrected mean number of fish by age class and habitat type was then multiplied by the total number of habitat units of each type in the entire drainage to estimate the basin-wide number of individuals. Approximate 95% confidence intervals were calculated for the basin-wide estimates using the methods of Hankin and Reeves (1988) and Dolloff et al. (1993).

Boulder and Myrtle creeks were also surveyed to assess their individual contributions to potential recruitment. The same calibration ratios developed for the Deep Creek drainage were used for Boulder and Myrtle creeks. This was justified because the three drainages had similar discharge and visibility.

Outmigrant trapping

We used a rotary-screw trap (Thedinga et al. 1994, Kennen et al. 1994) to capture juvenile rainbow trout outmigrating from the Deep Creek drainage to the Kootenai River. The trap was located on Deep Creek near Moravia (Figure 2). It was operated from April 12 to 19, May 24 to July 17, and from September 24 to October 30, 1997. The trap was removed to avoid potential damage from high flows and debris in April and again removed on July 17 when flows dropped to levels too low to operate the trap (< $0.08 m^3/s$). An inclined plane style trap (Fredericks, in press) was installed to replace the screw trap on August 15, but proved ineffective in trapping outmigrants. On September 24, a flow deflector was installed in Deep Creek to increase water velocity to levels sufficient to turn the screw trap. The deflector was constructed of four 1.22 m x 2.44 m sheets of plywood wired to 2.44 m steel fence posts anchored in the substrate. Approximately 75% of the channel width was blocked by the deflector and the majority of the water was funneled into the mouth of the trap at an increased velocity of approximately 0.09 - 0.1 m^3/s. This proved to be a sufficient velocity to keep the trap in operation through the end of the trapping season (October 31, 1997).

All rainbow trout captured were weighed (g) and measured (TL). Scales were taken from a random subsample of captured fish for aging. In addition, saggital otoliths were used to estimate the ages of outmigrants captured in October. A mark-recapture technique was employed to estimate trap efficiency for juvenile rainbow trout (Seelbach et al. 1985, Kennen et al. 1994, Thedinga et al. 1994, Roper 1995). Juvenile rainbow trout were fin-clipped and released approximately 400 m above the trap to ensure mixing with the unmarked population. Fish were marked differently on a four day rotating schedule (i.e., right pelvic, day one; left pelvic, day two; upper caudal, day three; and lower caudal, day four; then repeat the cycle). By using different marks each day, it was possible to estimate daily trap efficiencies. Daily efficiencies have been shown to provide more accurate estimates of total outmigration when trap efficiencies vary (Roper 1995).

The proportion of marked fish recaptured provides an estimate of trap efficiency (TE) as (Thedinga et al. 1994):

$$TE = R/M \tag{1}$$

where:

R = number of recaptures
M = number of marks

The variance (V) for the TE was estimated as (Seelbach et al 1985):

$$V = pq/M \tag{2}$$

where:

P = TE
q = 1-p

To minimize potential bias associated with small sample size, I pooled days for calculation of TE until a minimum number of four recaptures (Ricker 1975) and 40 marks was reached. In effect, I let sample size determine the strata for calculation of TE. Following calculation of TE based on a minimum mark and recapture sample size, I pooled the mark-recapture data for concurrent strata (time periods) if trap efficiencies were not significantly different based on a chi-square test (Rawson 1984). This increased sample size and reduced variability in the TE estimate, resulting in tighter confidence intervals around the point estimate of outmigration. The TE was used to estimate the total number of outmigrants from the unmarked catch for a given time period as (Thedinga et al. 1994):

$$N_t = U_t/TE_t \tag{3}$$

where:

N_t = outmigrant estimate for time period t
U_t = unmarked catch for time period t
TE_t = trap efficiency for time period t.

The 95% confidence intervals for the outmigration estimate were derived by substituting the upper and lower boundary of the confidence interval for trap efficiency into the formula used to calculate outmigration (equation 3).

There were periods of time when the screw trap was not operated. To estimate outmigration during these periods, I assumed the mean daily outmigration for the periods the trap was operated accurately approximated the mean daily outmigration for the days the trap was not operated, during a given month. The screw trap was not operated in August so the outmigrant estimate for September was used as an approximation, under the assumption that similar flows result in similar outmigration.

On April 12, 1997 a staff gage was installed in Deep Creek to record relative flows. Linear regression was used to explore the predictive ability of gage height for trap efficiency and daily outmigration.

Adult Sampling

In addition to incidental catches of post-spawn adult rainbow trout in the screw trap, spawners were captured by dip netting at a falls on Fall Creek, a tributary to Deep Creek (Figure 2). These sporadic efforts to capture adult rainbow trout by dip netting were conducted between May 28 and June 13, 1997. Captured rainbow trout greater than 180 mm had scales removed for aging and were marked with $10.00 reward T-bar anchor tags to estimate movement and exploitation rates.

RESULTS

Deep Creek Basin-wide Estimate

While sample size for snorkel counts was sufficiently large for both fast and slow water habitats (50% and 64% of total habitat units available, respectively), the sample size for the calibration ratios was about half of that recommended by Dolloff et al. (1993). Scatter plots and simple correlations of snorkeling and electrofishing suggest that snorkel estimates were fairly precise for all of the relationships with the exception of fish > 76 mm in fast water (Figures 3 and 4). Calibration ratios (R) ranged from 1.08 to 2.5 (Figures 3 and 4).

The total estimated numbers of age-0, age-1, and age-2 and older rainbow trout in the Deep, Boulder, and Myrtle Creek drainages in 1997 were 30,023; 763; and 235, respectively (Table 1). Trail Creek had the highest estimated density of age-0 rainbow trout in 1997 and the second highest density of age-1 and older rainbow trout. Reach one of Deep Creek had the lowest mean densities of rainbow trout for all age classes (Appendix A).

A single bull trout was observed by snorkeling in 1997. This fish was approximately 125 mm TL and was observed in Myrtle Creek on August 25, 1997.

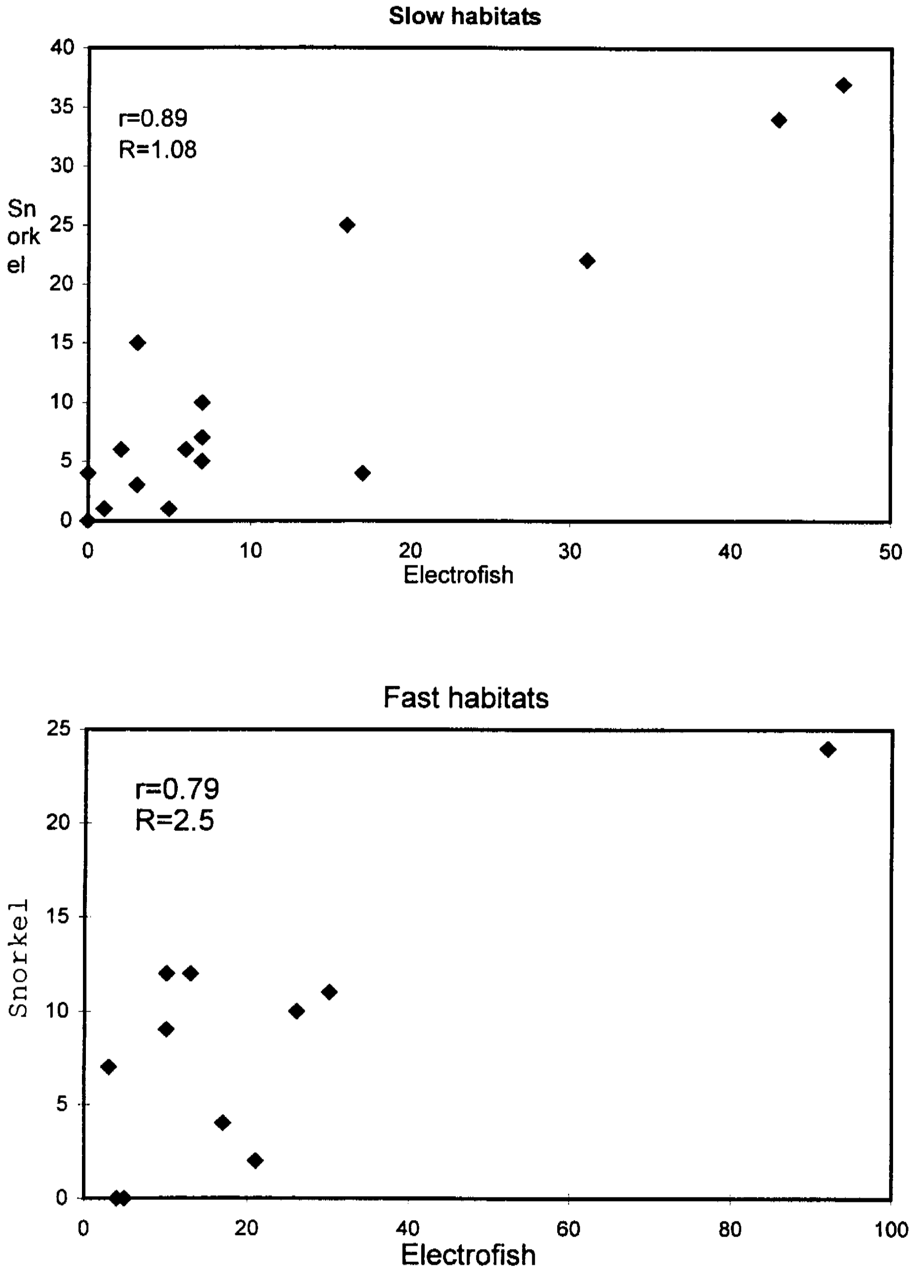
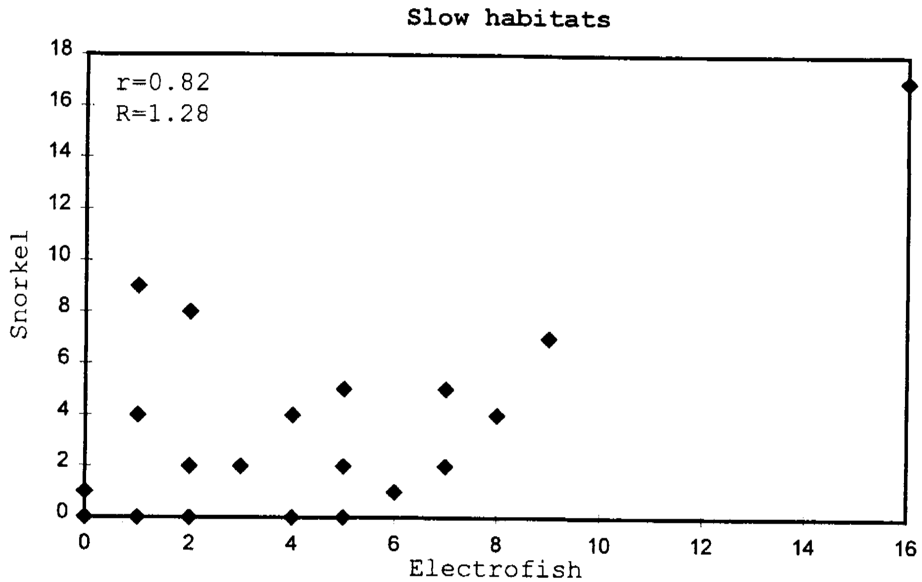


Figure 3. Simple correlations (r) between electrofishing estimates and snorkel counts, and calibration ratios (R) for snorkel counts of age-0 rainbow trout in the Deep Creek drainage, Idaho during 1997.



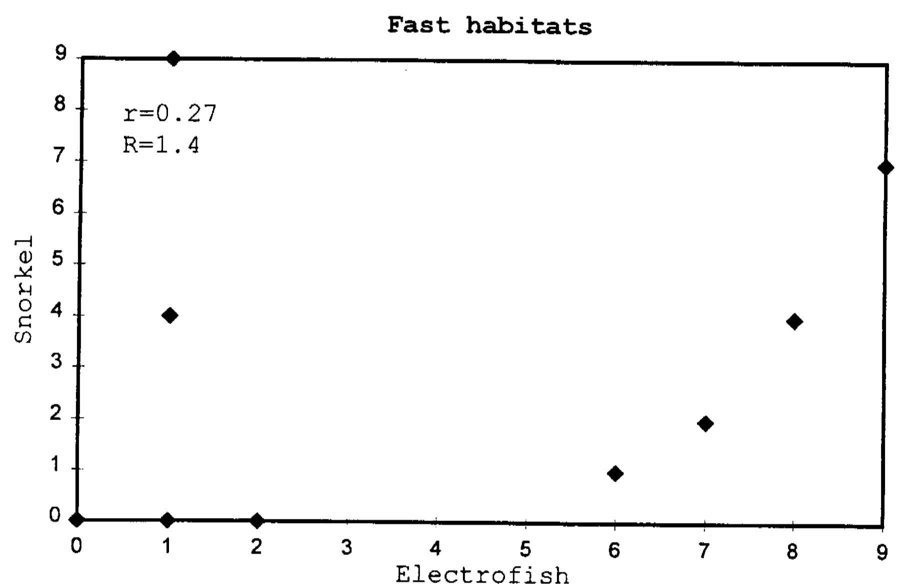


Figure 4. Simple correlations (r) between electrofishing estimates and snorkel counts, and calibration ratios (R) for snorkel counts of age-1 rainbow trout in the Deep Creek drainage, Idaho during 1997.

Table 1. Estimated numbers and approximate 95% confidence intervals (CI) of rainbow trout by age class in the Deep, Boulder, and Myrtle creek drainages during late July through August, 1996 and 1997.

Drainage	Year	Age-0 (CI)	Age-1 (CI)	Age-2 and older
Deep	1997	25,385 (3,536)	4,063 (1,338)	575
	1996	63,743 (6,310)	12,909 (1,359)	3,095 (678)
Boulder	1997	659 (191)	85 (70)	19
	1996	1,050 (579)	347 (233)	103 (97)
Myrtle	1997	50 (76)	145 (29)	40
	1996	117 (93)	110 (56)	62 (56)

Outmigrant trapping

Length-frequency analysis was used to estimate the age composition of outmigrating juvenile rainbow trout in April 1997. Two distinct peaks suggest the outmigration was dominated by age-1 fish with lesser numbers of age-2 and older individuals (Figure 5).

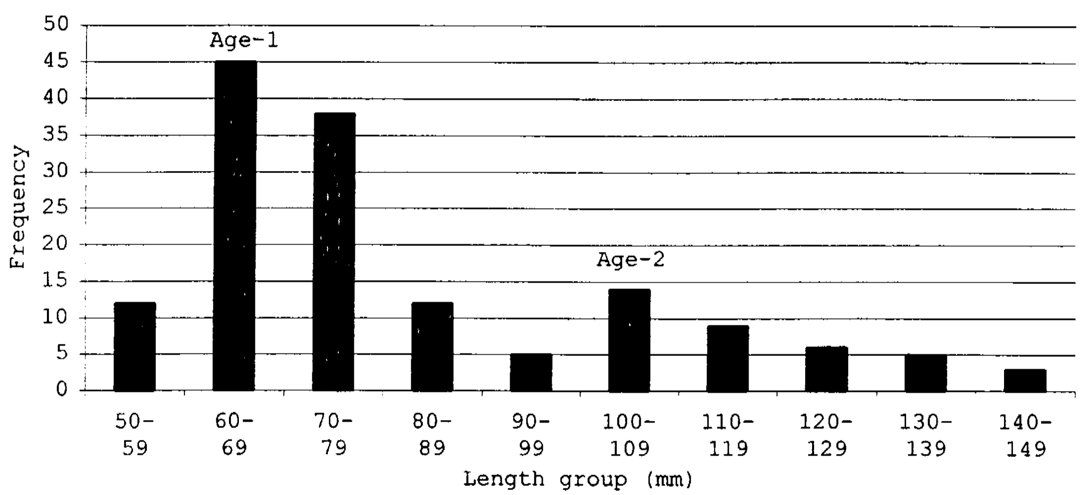


Figure 5. Length-frequency histogram of rainbow trout outmigrants captured in Deep Creek, Idaho during April 1997.

We attempted to use length frequency analysis to examine the age distribution of outmigrating juvenile rainbow trout in June, however, due to highly variable growth rates in tributary streams it was not possible to identify modal peaks (Figure 6).

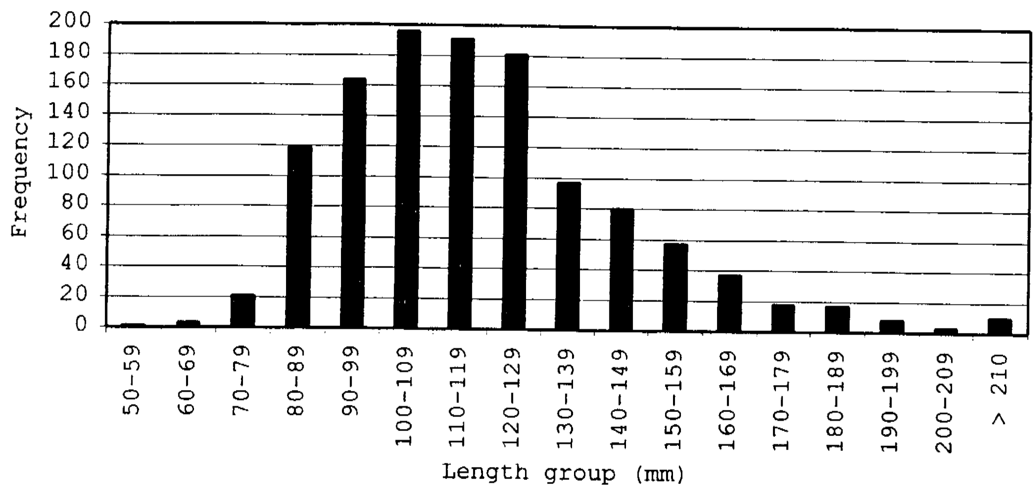


Figure 6. Length-frequency histogram for rainbow trout outmigrants captured in Deep Creek, Idaho during June 1997.

Scales were used to age juveniles in June and suggested 75% of the outmigration for this time period was comprised of age-1 fish, with the remainder made up of age-2 and older fish. By October, the outmigration was dominated by age-0 and age-1 rainbow trout based on length-frequency analysis. The ages assigned by length-frequency were confirmed by aging whole otoliths (Figure 7).

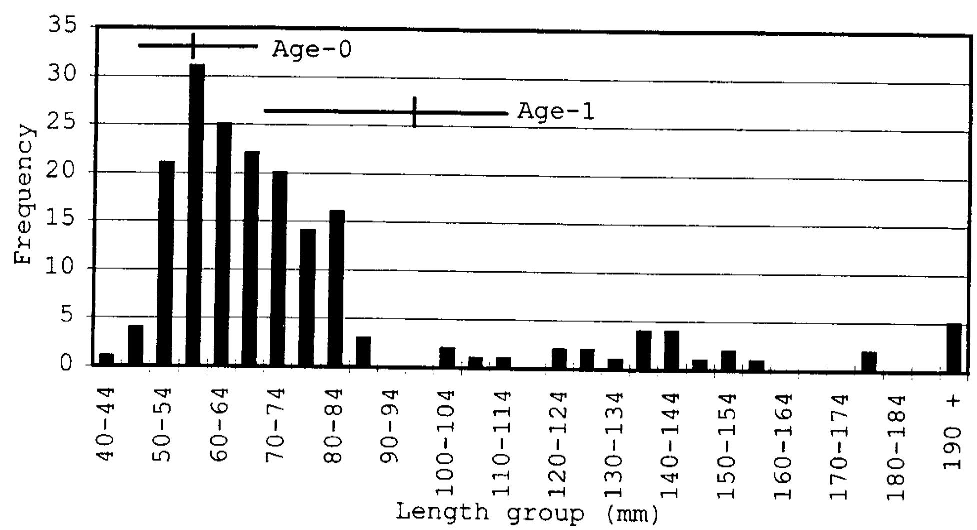


Figure 7. Length-frequency histogram of outmigrant rainbow trout collected in Deep Creek, Idaho in October 1997. Horizontal bars represent length ranges and the vertical cross-bar represents the mean length for ages assigned by otoliths (n=23).

Screw trap efficiencies for individual strata ranged from 5.4% to 38% from April to October 1997. Daily TEs were not significantly different for any of the strata within both of the months, June (Chi-square test; d.f. = 10; $p > 0.1$) and October (Chi-square test; d.f. = 3; $p > 0.1$) (Rawson 1984). Therefore, marks and recaptures were pooled within these months to produce one estimate of TE for each (Table 2). For the months April, May, and July, sample sizes permitted only the calculation of one TE for each month. Number of recaptures was insufficient to produce an estimate of TE for September so I used the TE for October as an approximation.

Table 2. Trap efficiencies (TE) and approximate 95% confidence intervals (CI) for Deep Creek, Idaho.

Month	Marked Trout	Recaptured Marked Trout	TE	95% CI (TE)
April	112	6	.05	.04
June	847	121	.14	.02
July	65	18	.28	.11
October	203	37	.18	.05

Although a staff gage was installed on Deep Creek in 1997, the number of actual flow measurements was insufficient to establish a strong gage height-discharge relationship. Gage height was a significant predictor of both TE ($r^2 = 0.36$, $.01 < p < .05$) and outmigrant numbers ($r^2 = 0.56$, $p < 0.001$), but a large proportion of the variance remained unexplained in both models.

The number of estimated outmigrants, 15,066, is based only on the days the screw trap was in operation (Table 3). However, this only represents approximately 30% of the days from April 1 to October 30, 1997. When the estimate is expanded to include those days the trap was not fished, the resulting estimate is 38,206 (Table 3). The majority of the outmigration (88%) occurred during the months of April, May, and June. This time period also corresponds to the months of active spawning and egg incubation for rainbow trout in the Deep Creek drainage. Therefore, a conservative estimate of the proportion of the total outmigration comprised of age-1 and older individuals during the trapping period would exceed 80%.

In addition to rainbow trout, 12 other species were captured by the screw trap. These included juvenile and adult kokanee, brook trout *Salvelinus fontinalis*, mountain whitefish, longnose sucker *Catostomus catostomus*, peamouth *Mylocheilus caurinus*, Northern squawfish *Ptychocheilus oregonensis*, redside shiner *Richardsonius balteatus*, longnose dace *Rhinichthys cataractae*, brown bullhead *Ameiurus nebulosus*, yellow perch *Perca flavescens*, largemouth bass *Micropterus salmoides*, sculpin *Cottus sp.*, and pumpkinseed *Lepomis gibbosus* (Table 4).

Table 3. Estimates and 95% confidence intervals (CI) of outmigrating juvenile rainbow trout in Deep Creek, Idaho during 1997.

Month	Outmigrant Estimate[a]	Upper CI[a]	Lower CI[a]	Expanded Estimate[b]
April	2,860	14,300	1,589	12,258
May	2,100	2,526	1,798	13,286
June	7,910	9,511	6,771	8,240
July	593	977	426	1,893
August	N/A	N/A	N/A	496
September	116	164	89	496
October	1,487	2,116	1,146	1,537
Total	15,066	29,594	11,819	38,206

[a] Estimate for days trap was operated
[b] Estimate extrapolated to unfished periods

Table 4. Screw trap catch composition by number for species other than rainbow trout in Deep Creek, Idaho during 1997.

Species	Number captured
Yellow perch	5,559
Longnose dace	188
Redside shiner	145
Sucker sp.	96
Northern squawfish	84
Mountain whitefish	41
Peamouth	31
Kokanee	27
Pumpkinseed	25
Largemouth bass	23
Bluegill	1
Eastern brook trout	1
Sculpin sp.	1

Adult Sampling

A total of 43 adult rainbow trout (> 180 mm) from the spawning migration were captured by trapping and netting in the Deep Creek drainage between May 28 and July 4, 1997. Captured individuals ranged in length from 180 to 485 mm. Of these, 42 were tagged with the T-bar style reward tags and released. Scale analysis suggests the majority of these fish were age-4 and -5 (Figure 8). Three of the tagged fish were harvested, all in Kootenay Lake, BC, resulting in a minimum estimated harvest rate of marked fish of 7%.

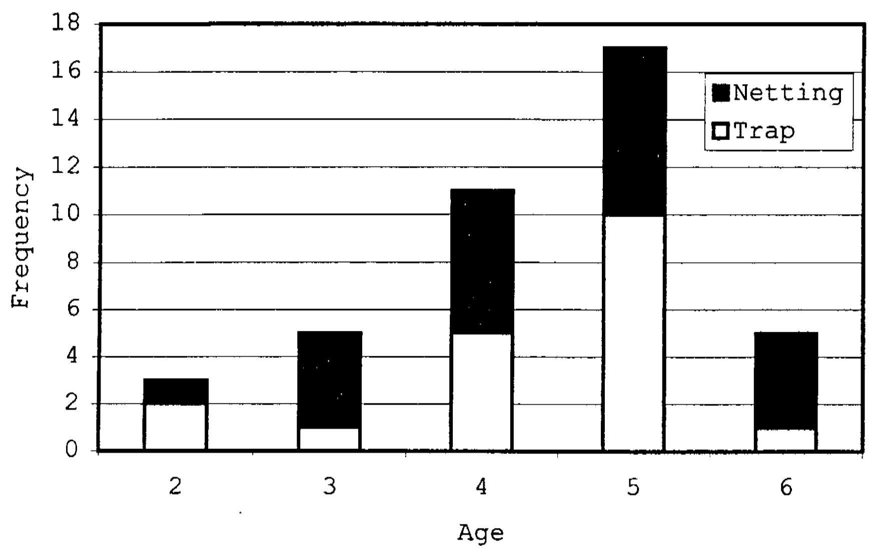


Figure 8. Age distribution based on scale analysis of captured adult (>180 mm) rainbow trout in the Deep Creek drainage, Idaho, between May 25 and July 4, 1997.

DISCUSSION

Deep Creek Basin-wide Estimate

The 1997 Deep Creek basin-wide estimate was considerably lower than the 1996 estimate. Fredericks (in press) reported a point estimate of 79,747 rainbow trout compared to the 1997 estimate of 30,023 (Table 1). Although the spawning run has not been effectively quantified, it is unlikely that the difference in rainbow trout abundance estimates between these years in the Deep Creek drainage is accurate. This conclusion is based on comparison of densities of juvenile rainbow trout by habitat type for the most important tributaries relative to juvenile rainbow trout production in the Deep Creek drainage. Based on juvenile rainbow trout density estimates, Partridge (1983), Paragamian (1994), Fredericks (in press), and this study suggest that the most important tributaries for juvenile production are Trail, Ruby, Fall, Dodge, and Browns creeks. Although statistical comparisons were not made, densities observed in 1997 in these tributaries do not appear to differ markedly from observed densities in 1996 (Appendix A), with the exception of Browns Creek. Densities in Browns Creek were higher in 1997 than those reported in 1996. This suggests the difference in the basin-wide estimates between 1996 and 1997 is the result of other factors. Fredericks (in press) reported much higher densities of juvenile rainbow trout in Deep Creek in 1996 than were observed in 1997 (Appendix A). A partial explanation may be that in 1996, Deep Creek was sampled approximately two weeks to one month after sampling was conducted in Trail, Ruby, and Fall creeks. This would allow adequate time for juvenile rainbow to migrate downstream to Deep Creek, where they may have been counted again. In 1997, Deep Creek was sampled prior to Trail, Ruby, and Fall creeks to avoid double counting fish. In addition, Deep Creek was sampled from July 16 through 25, 1997 versus August 23 to October 1, 1996. The earlier sampling period in 1997 would be a more accurate gauge of production and suggests Deep Creek itself is not a major producer of juvenile rainbow trout.

The lack of production in Deep Creek likely results from embedded substrates, degraded streambanks, and high summer water temperatures (reported to exceed 25°C in July) (Fredericks, in press). However, its value as over-winter habitat may be more significant.

Analysis of the population estimates was conducted using two different techniques. Fredericks (in press) used a two-stage ratio type estimator and expanded the estimate using habitat surface area (n/m^2). While this method was appropriate for 1996, it was not appropriate for the 1997 data. Correlations between habitat surface area and fish density were insignificant for both fast and slow habitat types ($p > 0.1$, $r < 0.45$) in 1997. The lack of significant correlation in 1997 may be related to the small sample size (< 5% of habitat units were sampled by electrofishing), but it also demonstrates that fish are not uniformly distributed. It may be legitimate to expand a density estimate by surface area in more uniform type habitats such as riffles and pocket water, but not in pools and glides where cover components are not evenly distributed.

The method used in 1997 to estimate the basin-wide abundance of rainbow trout (Hankin and Reeves 1988, Dolloff et al. 1993) expands the estimate to unsampled waters using a mean density of fish per habitat unit and then uses the number of habitat units as the expansion factor. This method is sensitive to differences in habitat typing, but was the most appropriate estimator for the 1997 data because of the lack of significant correlation between surface area and fish density. Differences in water years would directly influence the habitat typing. Using flow data from the US Geological Survey Yaak River Gaging Station, peak flows were substantially higher in 1997 than 1996 (356.6 m^3/s versus 225.6 m^3/s, respectively).

A basin-wide estimate, conducted on a migratory population, would be sensitive to annual variations in timing of the survey, spawning, emergence, mortality, and migration. Drastically different estimates may result without actual changes in true production. The value of these abundance estimates for age-0 rainbow trout is questionable.

Juvenile rainbow trout densities in some tributaries in the Deep Creek drainage could be considered good despite the embedded substrates and poor condition of the riparian area. Mean densities of juvenile rainbow trout (age-0 and age-1) exceeded 60/100 m^2 in Browns, Dodge, Ruby, and Trail creeks (Appendix A). For comparison, Hoelscher and Bjornn (1987) estimated mean reach densities ranging from 11/100 m^2 to 56/100 m^2 in six tributaries to Lake

Pend Oreille. Lider and Techau (1994) reported juvenile cutthroat trout (age-0 only) densities in 17 streams in the Coeur d'Alene drainage were generally less than 10 fish/100 m^2, but ranged as high 300 fish/100 m^2 from 1985 to 1993. Lukens et al. (1976) estimated juvenile trout densities from 59/100 m^2 to 500/100 m^2 in Wolf Lodge Creek, an important cutthroat trout spawning and rearing tributary to Lake Coeur d'Alene.

Some individual points may have had unfair influence in the snorkel-electrofishing comparisons, giving the appearance of high correlations (Figure 4). Removing these points from the analysis reduced the correlation values, but dropping them from the analysis was not justified because the data points were legitimate. I analyzed the data with and without the outlying points, and the overall effect on the population estimates was minimal.

Outmigrant trapping

Results from outmigrant trapping are more consistent than the basin-wide estimates. Fredericks (in press) reported a total outmigrant estimate of 51,500 rainbow trout from April through October 1996. We estimated total outmigration at 38,206 rainbow trout for the same time period in 1997. The consistency in these results suggests trapping is a more precise method for estimating the potential contribution of the Deep Creek drainage to the Kootenai River fishery than a basin-wide population estimate. Because the trap is run continuously, it will not be sensitive to yearly changes in the timing of sampling, spawning, emergence, mortality, and migration.

It was necessary to place the screw trap on Deep Creek above the confluence of both Snow and Caribou creeks to assure adequate water velocities to turn the trap. Below these tributaries, both low stream gradient and the backwater influence of the mainstem Kootenai River serve to reduce water velocities. This does not result in a significant bias in the total outmigration estimate of Deep Creek because these tributaries do not support high densities of juvenile rainbow trout (Appendix A).

Trapping results from 1997 suggest that peak outmigration occurred from April through June (Table 3). Fredericks (in press) reported similar timing of peak outmigration during 1996. Peak outmigration appears to correspond with increasing stream discharge and will fluctuate with the timing of spring runoff.

The 1997 outmigration of rainbow trout from the Deep Creek drainage was dominated by age-1 fish in both April and June and by age-0 fish by October. Fredericks (in press) reported an even proportion of age-1 and age-2 fish in the outmigrant catch from April through July, 1996, as compared to our estimate of 75% age-1 and 25% age-2 and older fish for the same time period in 1997. The even age distribution at the trap in April through July 1996 could have resulted from a weak 1995 year class or more likely, from aging bias. The non-normal distribution of lengths for age-1 rainbow trout in June and July (Figure 9) suggests that there is bias in the sample.

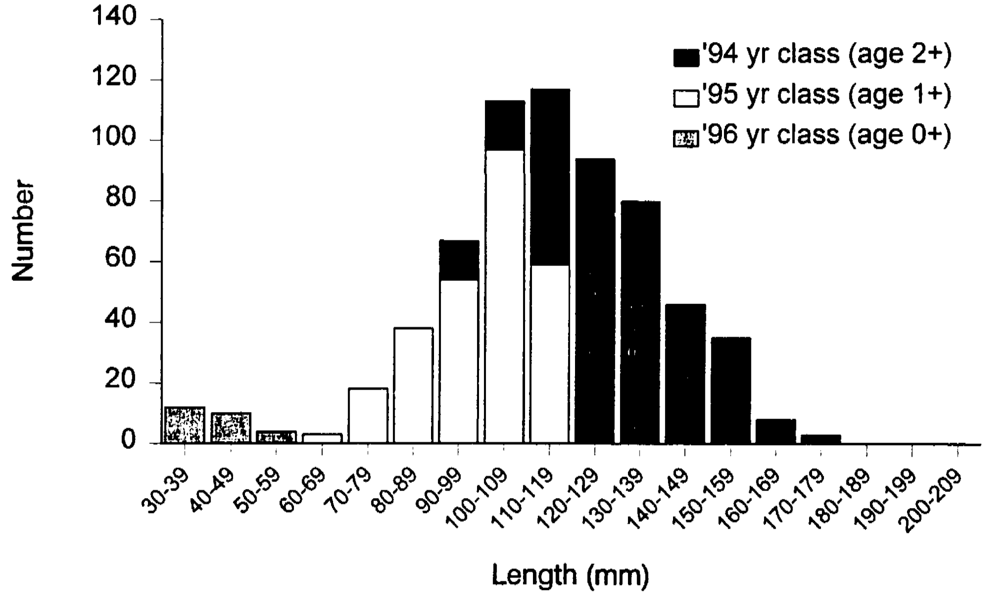


Figure 9. Length-frequency distribution of outmigrating rainbow trout in Deep Creek, Idaho during June and July, 1996 (adapted from Fredericks, in press).

Adult Sampling

Exploitation of tagged rainbow trout was low; only three were reported harvested in 1997. Despite the small sample size, the fact that all three of the harvested rainbow trout were from Kootenay Lake, BC, suggests at a minimum, an adfluvial component to the Deep Creek drainage spawning stock. Fredericks (in press) reported the one radio-tagged fish located after outmigrating to the Kootenai River moved downstream to the vicinity of Myrtle Creek (Rkm 234), where it remained from June 18 to October 21. Assuming this fish was exhibiting a fluvial life-history, the spawning run in the Deep Creek drainage may be a mixed stock comprised of adfluvial fish from Kootenay Lake and fluvial fish from the Kootenai River. Continued reward and radio-tagging in 1998 will provide further insight into the stock make-up of the spawning population of Deep Creek.

Even when small sample size is considered, it appears that the collection of the 43 adult spawners was unbiased (Figure 8). Similar proportions of ages were captured by trapping and netting. Based on this assumption, the spawning run was comprised mainly of age-4 and -5 rainbow trout. Lesser numbers of age-2, -3, and -6 year old fish were captured. This is consistent with rainbow trout age at maturity in Kootenay Lake for the non-Girard strain (B. Lindsay, BC Ministry of Environment, Lands and Parks, personal communication).

Recruitment Overview

Fredericks (in press) suggested that poor recruitment, resulting from insufficient juvenile production, may be limiting the Kootenai River rainbow trout population. This could be true if the majority of the juvenile rainbow trout produced in Deep Creek are being recruited to

Kootenay Lake, BC The Moyie River may also contribute recruits to the Kootenai River. Approximately 2 km of the Moyie River is accessible to rainbow trout inhabiting the Kootenai River. Local anglers report good fishing for 10 to 12 inch rainbow trout in this reach of the Moyie River during summer months. However, Paragamian (1994) was unsuccessful at capturing any rainbow trout during an electrofishing survey in this reach of the Moyie River in 1993. Without production from Deep Creek, no major source of rainbow trout recruits in the Idaho reach of the Kootenai River is known.

However, there are many other important factors, which have not been examined. For example, juvenile habitat and food availability can play a major role in recruitment. The conclusion that the Kootenai River is recruitment limited due to inadequate juvenile production without knowledge relating to habitat, movement, and forage availability is premature. The canyon and braided reaches of the Kootenai River, reported to contain the highest quality rainbow trout habitat in the Idaho reach (Fredericks, in press), are currently classified as ultra-oligotrophic (Richards 1997). Lake Koocanusa acts as a nutrient sink, retaining approximately 63% of the total phosphorus entering it (Richards 1997). Snyder and Minshall (1996) concluded that ambient phosphorus levels limited periphyton growth in the Idaho portion of the Kootenai River. Periphyton is a major autotrophic component in river systems and is at the base of the food web (Snyder and Minshall 1996). The authors created an energy budget based on autotrophic (periphyton) production and the input of transported organic matter. They concluded that macroinvertebrates were limited by autotrophic production. The energy budget indicated there were periods during the year (June, July, and August) when autotrophic production could support increased densities of macroinvertebrates, but these periods were too short for the macroinvertebrates to capitalize and increase their biomass. This energy budget also indicated that ultimately, fish were limited at all times by autotrophic production. The authors proposed bottom-up food limitation (Carpenter et al. 1985, McQueen et al. 1989), caused by low nutrient levels, as the mechanism behind declining fish populations. Productivity, along with other factors, may be co-limiting the rainbow trout population in the Idaho reach of the Kootenai River.

Altering the selective withdrawal system of Libby Dam to increase the nutrient load to the Kootenai River is not likely to succeed. This is due to a lack of substantial nutrient stratification in Lake Koocanusa (Snyder and Minshall 1996). An alternative, which may prove effective to increase productivity in the Kootenai River, is nutrient enhancement. A nutrient addition experiment would be possible in which phosphorus could be added to the Kootenai River in Idaho to increase productivity and ultimately, fish abundance. As nutrients tend to spiral downstream, the experiment would be reversible simply by stopping the supplementation.

Our lack of knowledge concerning rainbow trout recruitment and population dynamics in the mainstem Kootenai River underscores the need for continued tagging and movement studies. Tagging will provide valuable information pertaining to the stock make-up and life history of the rainbow trout population spawning in the Deep Creek drainage. Outmigrant trapping will allow monitoring of relative reproductive success between years. In addition, future electrofishing population estimates will provide information on population levels, movement, and relative year-class strength.

RECOMMENDATIONS

1. Trap migrating adult rainbow trout in the Deep Creek drainage to implant radio and reward-tags, and quantify run size.
2. Use radio-tags and aerial telemetry to track spawning rainbow trout to identify life-history strategy and macro-habitat use.
3. Estimate population by age class of rainbow trout in selected reaches of the Kootenai River in Idaho to provide baseline information.
4. Survey mainstem Kootenai River above Bonners Ferry and accessible reach of the Moyie River for spawning and juvenile rearing activity.
5. Continue outmigrant trapping on Deep Creek to monitor juvenile rainbow trout population.
6. Explore the prospects of nutrient enhancement to improve the rainbow trout fishery through a literature review and the Adaptive Ecosystem Assessment Method.

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APPENDICES

Appendix A. Estimated density of age-0, age-1, and age-2 (and older) rainbow trout (number/100 m^2) by habitat type in tributaries of the Deep Creek drainage, Idaho during the summers of 1996 and 1997.

Stream	Year	Pool Age-0	Riffle Age-0	Glide Age-0	PW[a] Age-0	Pool Age-1	Riffle Age-1	Glide Age-1	PW Age-1	Pool Age-2	Riffle Age-2	Glide Age-2	PW Age-2
Boulder Cr.	1997	4.9	3.4	0.3	1.1	17	9.5	0	12.8	0.5	0.1	0	0
	1996	7.9	3.5	7.9	3.5	2.9	1.1	2.9	1.1	0.9	0.3	0.9	0.3
Browns Cr.	1997	65.8	38.1	65.1	--	23.8	3.4	9.9	--	1.4	0.07	0.13	--
	1996	0.01	--	0.25	--	0.14	--	0.13	--	0.03	--	0.01	--
Caribou Cr.	1997	2.9	11.1	20.2	0.7	6.4	1.9	2.3	2.7	0.9	0	0	0
	1996	20.1	15.2	69.2	15.2	9.2	4.0	8.3	4.0	5.5	1.1	3	1.1
Deep Cr. R-1	1997	0.002	0	0.002	--	0.02	0.007	0	--	0.02	0.008	0	--
	1996	0.2	0.4	0.8	--	0.1	0.6	0.2	--	0	0	0	--
Deep Cr. R-2	1997	0.006	0.01	0.01	--	0.007	0.03	0.004	--	0.001	0.007	0.001	--
	1996	5.6	16.8	12.1	--	6.0	4.6	3.1	--	2.3	0.4	0.6	--
Dodge Cr.	1997	53.7	47.9	39.3	--	31.2	1.4	8.2	--	6.2	0	2.0	--
	1996	51.0	62.7	52.9	--	5.1	0	1.8	--	0.7	0	1.5	--
Fall Cr.	1997	11.1	50.7	40.9	--	6.8	3.1	3.0	--	3.1	0.8	0.4	--
	1996	76.6	37.2	28.2	--	13.9	4.3	6.4	--	1.6	0.9	1.9	--
Myrtle Cr.	1997	3.5	1.3	4	--	10.0	5.4	1.5	--	3.8	1.7	0.5	--
	1996	1.0	2.1	1.0	2.1	4.1	0.8	4.1	0.8	3.6	0	3.6	0
Ruby Cr.	1997	88.8	38.0	72.8	22.6	52.7	7.2	16.8	14.9	10.2	0.4	2.5	0.6
	1996	86.8	68.2	82.4	51.8	17.9	11.3	12.5	15.4	9.3	0.5	4.8	0.9
Snow Cr.	1997	3.8	3.6	8.2	1.2	9.4	1.3	0.9	4.0	2.1	0	.08	0
	1996	30.7	7.4	32.1	7.4	1.7	0.4	5.4	0.4	0.8	0.4	0	0.4
Trail Cr.	1997	95.3	98.9	115.2	83.3	21.1	14.2	18.5	8.6	8.0	0.3	1.8	1.1
	1996	139.4	81.0	118.2	75.8	35.4	5.4	17.7	9.6	16.3	0.8	2.6	0.8

[a] PW Pocket wat

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